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INFLUENCE OF NICKEL & MANGANESE PARTICLES ON COPPER METAL MATRIX COMPOSITE FOR HEAT EXCHANGER TUBES

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ABSTRACT

Composites are ideal for applications in corrosive environments such as marine applications. The main reason for composite materials used in marine structures as their high specific properties, with their corrosion resistance and light-weighting attributes. Metal matrix composite materials are widely used in various marine applications due to good durability in sea water superior performance. And also due to the ability to withstand saline water. Cu-Ni alloys were widely consumed process of removing salt from seawater. This technology has used in various fields such as marine, power stations, automobiles, aircraft, etc.

Metal matrix composite is prepared by powder metallurgy technique. In terms of varying, the percentage of reinforcement such as nickel and manganese particles with copper alloys have good work hardening. The salt spray test was studied in this paper to find a corrosion behavior of MMC and to determine the corrosion rate by calculating the weight reduction of the material. It seems that manganese composite expressed tremendous corrosion when dipping in a 5% sodium chloride solution.

KEYWORDS: Copper, Nickel, Manganese, Powder Metallurgy, Corrosion & Salt Spray Test

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Original Article

1. INTRODUCTION

Generally, a heat exchanger is a mechanical device to transfer the heat one fluid to another fluid medium where fluids are run through around the tubes. Over the fluid velocity on shell or tube heat exchangers cause erosion because of the formation of corrosion tube walls due to its environment. Therefore, the design of the heat exchanger mainly depends on suitable materials to conduct the heat properly.

Copper is the best choice of material for heat exchanger because of its excellent heat conduction property which reveals that copper has high thermal conductivity. And reaming properties of the heat exchanger are corrosion resistance, tensile strength, and yield strength which has fulfilled by copper. Copper and nickel alloy has high corrosion resistance for all environments especially saltwater. So it is used in the fabrication of heat exchanger tubes in seawater and also it reduces macro fouling. Iron and Manganese as a best- strengthening element for making copper and nickel alloy for accepting high pressure.

2. MATERIALS AND METHODS

Table 1 represents the chemical composition of Cu alloys and the 100-micron particle size of nickel & manganese as used reinforcing material.

Table 1: Chemical Composition

Ni	Mn	Cu
10%-30%	Upto 2 %	Remaining

2.1 Copper

Copper has good tensile strength, high electrical and thermal conductivity. It can't react with H_2O, but the help of atmospheric O_2 to develop a layer of brown-black CuO to resist corrosion.

Table 2: Properties of Copper

Properties	Copper
Melting point	1084.62°
Boling point	2562° C
Thermal conductivity	401w/(m.k)
Density	8.96 (g/cm³)

2.2 Nickel

Table 3: Properties of Nickel

Melting point	1445 °C
Boling point	2913 °C
Density	8.908 g/cm³
Brinell hardness	667-1600 Mpa

Nickel is a stronger, shiny, white metal. It acts as a major role in our day to day life such as batteries, kitchenware, jewels, automobiles, etc. Compared to other metal, it has more corrosion resistance and more strength can be obtained by higher temperature.

2.3 Manganese

Manganese is silvery metal. It has hard and brittle nature. It is found in nature and also easily oxidized.

Table 4: Properties of Manganese

Melting point	1246°C
Boling point	2,062°C
Density	7.21 gram/cm^3
Brinell hardness	500 a

2.4 Fabrication of Composite

The term "powder metallurgy" covers the art of producing objects from metal powders, with or without the addition of non-metallic constituents [6]. The fine particles are blended using lubricant.

The following proportions are to be used to making a composite specimen.

Table 5: Powder Percentages in Specimen

Specimens	Copper	Nickel	Manganese
1	90%	8%	2%
2	85%	13%	2%
3	80%	18%	2%
4	75%	23%	2%
5	70%	28%	2%

Compaction

Compaction is a process of packing a fine powders with close tolerance in mechanical press which having desired shape of die. The die has good hardness to withstand the load.

Sintering

It is a process of forming a solid specimen in heated medium whether using a pressure which depends on properties of powders. The temperature of furnace cannot exceed the melting temperature of the base material. During the diffusion process the control atmosphere maintained at a furnace. The furnace may be used either batch type or box type.

Figure 2.1: Sintered Specimens.

3. TESTING METHOD OF SALT SPRAY TEST

The 25mm diameter size of the specimen has cut in the ASTM B117 standard and 1200 grit emery paper was used to polish the work specimen. Finally, a diamond paste using a polishing machine to polished the specimen smoothly.

Figure 3.1: Salt Spray Test Chamber.

Then the specimens before dipping in the solution rinsed with distilled water and reduced the acetone chemical compound. The work specimen is to be tie with a nylon wire and dipping with closed salt fog chamber. The saline water is sprinkling continuously up to 24 hours and fog create inside the salt fog test chamber. The sodium chloride reacts with copper alloy metal and the white rust form on the surface. The results were calculated by loss of weight and the corrosion rate was measured by dipping the specimen in a period of one day. The Figure 3.1 displays the dipping specimen of the salt fog chamber.

4. RESULTS & DISCUSSIONS

4.1 Corrosion Behavior of Copper Composites

The corrosion behavior of investigators in figure 4.1(b) displays the mass loss and corrosion rate of copper metal matrix composites in the 3.5% Mn NaCl solution. In figure 4.1(a) illustration that the corrosion rate of a different sample with NaCl solution using 24 hours.

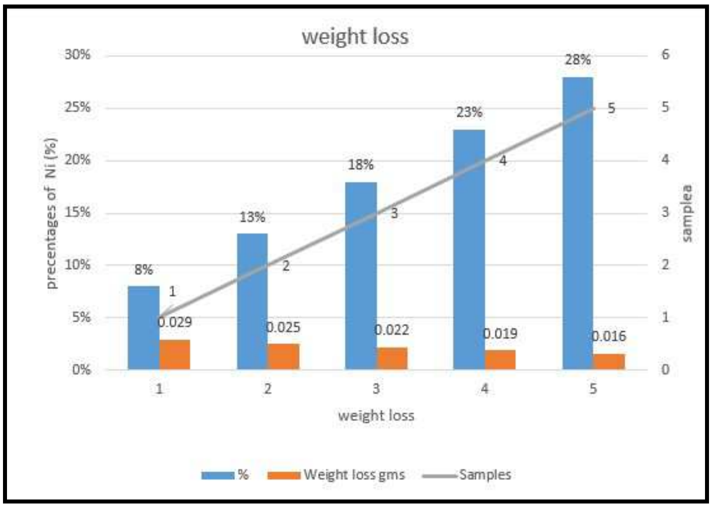

Figure 4.1(a): Corrosion Behavior of Copper Composites in 3.5% NaCl Solution.

The reinforcement of nickel as increase percentage up to 28% to decrease the weight loss of composites with additional reinforcement of manganese up to 2% decrease the weight loss of composition.

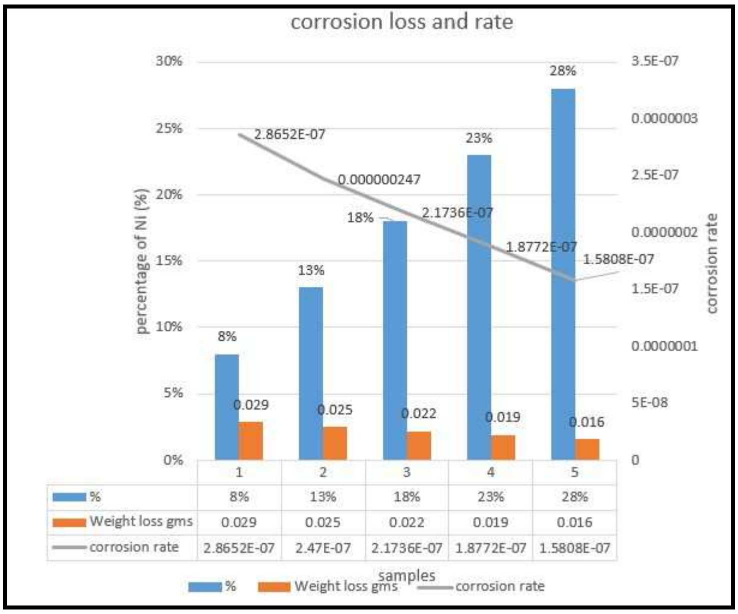

Figure 4.1(b): Graph of Weight Loss and Corrosion Rate.

This above graph shows the Cu-Ni-Mn metal matrix composite for combined result of weight loss and corrosion rate.

4.2 Mechanical Properties

Hardness was measured by B scale intender with a load of 10kgf, intender made of 1/16 inch steel ball. RH reveals that the

founded hardness value is much greater than existing Cu-Ni-Mn alloys. The reason of adding the manganese induces to rise the hardness of the alloys.

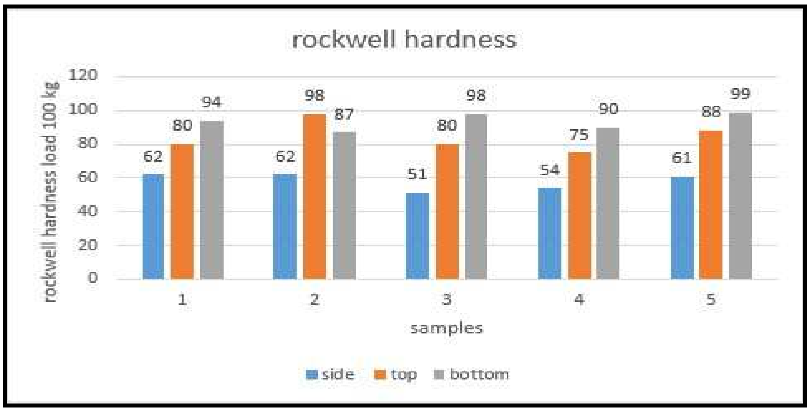

Figure 4.2: Graph of Rockwell Hardness Test.

4.3 Micro Structure

Physical Properties of final specimen depends on microstructure that influences the strength, toughness, ductility, hardness, corrosion resistance.

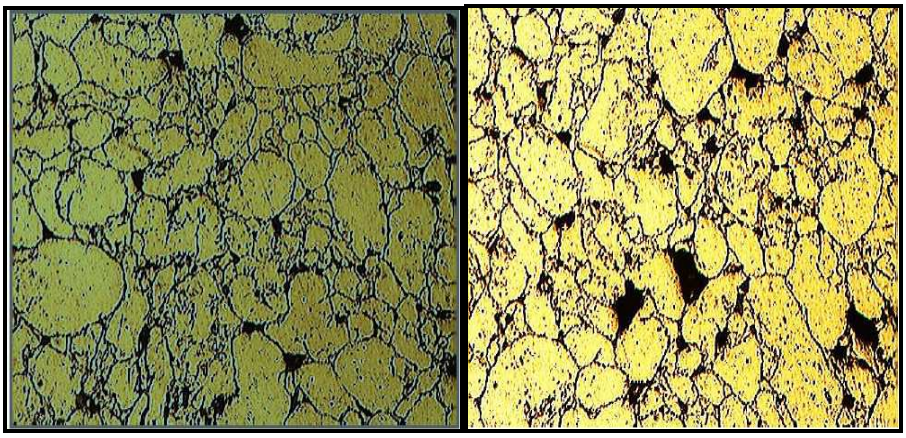

Figure 4.3: (a) Microscopic view of Polished Specimen at 100X Magnification.

Figure 4.3 (a) represents the powder metallurgical specimen in polished condition. The microstructure reveals, Copper matrix as grain boundaries and reinforcements as grains. Some of the pores present on the sample as dark spots.

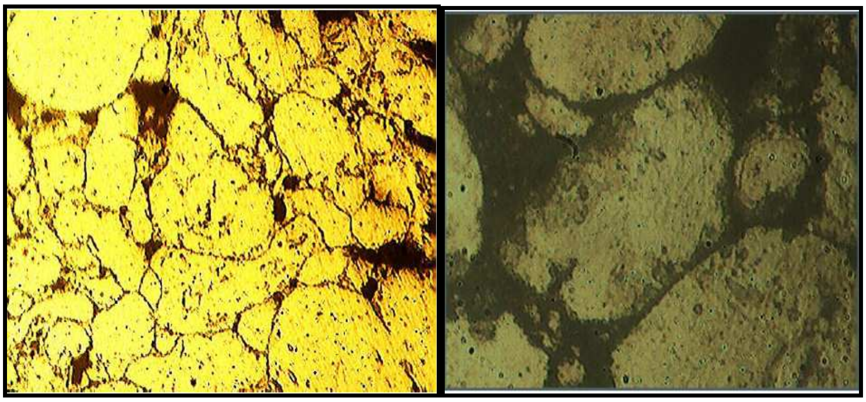

Figure 4.3: (b) Microscopic View of Polished Specimen at 200X Magnification.

Figure 4.3 (b) represents the final sample at 200X magnification. The scanned images shows grain size has 40 to 50 microns and percentage of pores is less than 8%

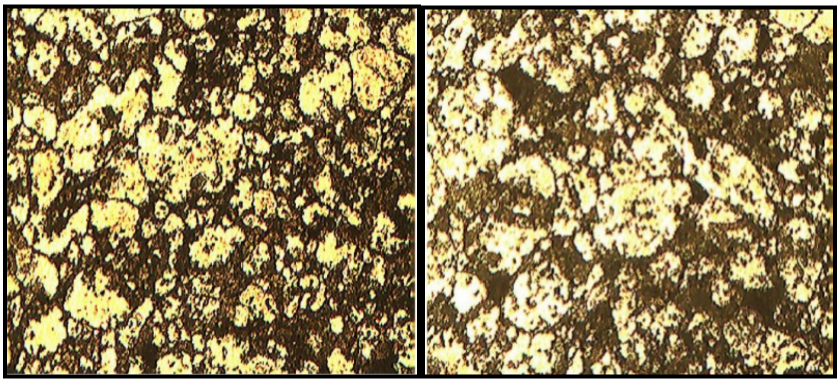

Figure 4.3 (c): Microscopic View of Etched Specimen at 100X Magnification.

Figure 4.3 (c) represents the powder metallurgical Specimen microstructure at 100X magnification. It reveals the white colored grains as alpha and it dispersed on matrix as beta phase with dark grain boundaries. The sample has pores as dark spots.

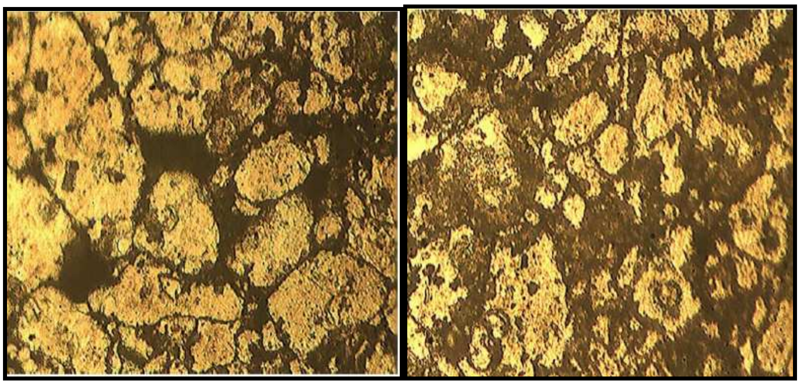

Figure 4.3 (d): Microscopic View of Etched Specimen at 200X Magnification.

Figure 4.3 (d) represents the specimen at 200X magnification which reveals the different phases and their grain boundaries.

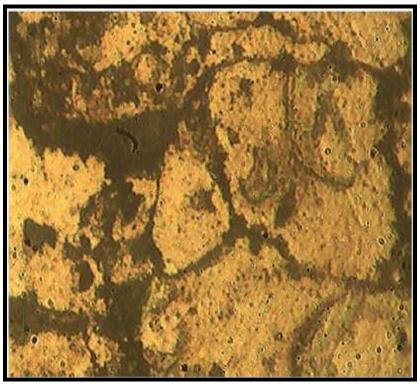

Figure 4.3 (e): Microscopic view of Etched Specimen at 500X Magnification

Figure 4.3 (e) represents the microstructure of final sample at 500X magnification that scanned image reavls nickel reinforcement on copper matrix has voids as dark spots.

5. CONCLUSIONS

The corrosion behavior of Cu alloy and MMC under 3.5% of solutions was studied. In different ratio of samples, the copper metal matrix composites with increasing nickel upto 28%, probably because of minimum addition of manganese to improve corrosion resistance of the specimen. So, the effect of Cu-Ni-Mn additions are decrease the corrosion rate of materials. The mass loss of the metal matrix composites decreased in 24hrs.

In this study, it was noticed that manganese composite exposed to good corrosion when dipping in 3.5% sodium chloride solution. Simultaneously, additions of the reinforcement on matrix phase are effecting the weight loss and corrosion rate has decreased. The final microstructure results uniform distribution of reinforced particles on matrix phase.

REFERENCES

1. *Badia, F. A., Kirby, G. N., and Mihalisin, J. R., "Strengthening of Annealed Cupro-Nickels by Chromium," ASM Trans. Quarterly, Vol. 60, No. 3, 1967, pp. 395-408.*
2. *Hosni M Ezuber, A. Al-Shater, [2], 1994 Copper-nickel alloys and in particular types 90/10 (UNS C70600) and 70/30 (UNS C71500) are the most common heat exchanger tubing materials to use in marine environments.*
3. *Jasner, M. Hecht and W. Beckmann, Heat Exchanger and Piping Systems from Copper Alloy Commissioning Operating and Shutdown, K. ME Publication 1098 005 104, 1998.*
4. *Krishna, V. M. Heat Transfer Enhancement by using CuO-Water Nanofluid in a Concentric Tube Heat Exchanger-An Experimental Study.*
5. *John Oldfield, 1976 Although their good thermal conductivity gives copper nickel a decided advantages.*
6. *Osborn, D. H., and Sudrabin, D. A,, "Copper Base Alloys: The jngical Choice for Marine Structures and Equipment," Proceedings 1A. CE 25th Conference, 1969.*
7. *Newson, J. E. (1946). Powder Metallurgy. Proceedings of the Institution of Mechanical Engineers, 154(1), 208–215.*
8. *Powell C. A. and H. T. Michels [4], 1994 Copper-nickel alloys for seawater corrosion resistance and Antifouling – A state of the art review, there are two main copper-nickel alloy grades used in marine service*
9. *Peters D. T. and H. T. Michels and C. A. Powell, Metallic Coatings for Corrosion Control of Marine Structures. International Workshop on Control for Marine Structures and Pipelines, Galveston, Texas. February 1999 (In Press, American Bureau of Shipping).*
10. *Srivastav, S. To Design and Study the Parameters of Gears using Powder Metallurgical Process.*
11. *Parameswaran (2018), experimental study on mechanical and corrosion characteristics of nab alloy with the addition of chromium.*
12. *Zhang Jie, 1999 Fe additions are widely added to enhance the corrosion resistance of cupronickel alloys.*
13. *Upadhyaya, G. S., Powder metallurgy technology. 1997: Cambridge Int Science Publishing.*
14. *German, R. M., Powder metallurgy and particulate materials processing: the processes, materials, products, properties, and applications. 2005: Metal powder industries federation Princeton.*
15. *Mallik S, Ekere N, Best C, Bhatti R. Investigation of thermal management materials for automotive electronic control units. Appl Therm Eng 2011; 31:355–62.*
16. *Ramaswamy, R., Selvam, B., Marimuthu, P., & Elango, N. (2018). Investigation of densification behaviour on yttrium oxide*

reinforced ti-6al-4v nano-composite through powder metallurgy. Int. J. Mech. Prod. Eng. Res. Dev, 8(2), 433-442.

17. *Molina A, Wang T, Zou C, Chen Z, Li M, Wang W, et al. In situ synthesis of TiB2 particulate reinforced copper matrix composite with a rotating magnetic field. Mater Des 2015; 65:280–8.*
18. *Moustafa SF, Abdel-Hamid Z, Abd-Elahi AM. Copper matrix SiC and Al2O3 particulate composites by powder metallurgy technique. Mater Lett 2002;53:244–9.*

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